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AI Smart Attendance System Using Face Recognition

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Abstract - In the era of digital transformation and big data, face recognition technology has emerged as one of the most effective biometric solutions for security, authentication, and automation across multiple domains, and this paper presents an advanced AI Smart Attendance System using Face Recognition based on real-time video processing to overcome the limitations of traditional attendance methods such as roll calls and manual signatures, which are time-consuming, error-prone, and susceptible to proxy attendance; the proposed system is designed with a focus on improving recognition accuracy, operational stability, real-time performance, and user-friendly interface design while ensuring scalability and cost-effectiveness. The system operates through four primary phases including database creation, face detection, face recognition, and automated attendance updating, where student facial data is collected and stored securely, faces are detected using Haar Cascade Classifiers, and recognition is performed using Local Binary Pattern Histogram (LBPH) as well as advanced deep learning models such as FaceNet for higher precision, enabling the system to process real-time classroom video streams and identify multiple students simultaneously with high efficiency; experimental results indicate that the system achieves approximately 82% accuracy in standard environments and can reach near 100% accuracy when integrated with cloud-based services such as AWS Rekognition, thereby significantly enhancing reliability and robustness. The implementation can be further extended using modern cloud infrastructure including Amazon S3 for secure storage, AWS Lambda for serverless execution, and DynamoDB for efficient database management, ensuring faster processing, scalability, and data security, while also reducing truancy rates by nearly 60% and minimizing instances of absenteeism, early departures, and classroom disruption. In addition to core functionality, the system introduces several advanced features such as real-time attendance dashboards, automated email notifications to faculty, analytics-based performance reports, and a parent access module, which allows parents or guardians to monitor their child's attendance through a web or mobile interface, receive instant alerts for absences, and track attendance trends, thereby increasing transparency, accountability, and parental involvement in education; further enhancements include QR-based backup attendance, anti-spoofing mechanisms to prevent fake face detection, mask detection compatibility, mobile camera-based attendance access, and integration with institutional ERP systems. Compared to other biometric systems like fingerprint and iris recognition, the proposed face recognition system is contactless, non-invasive, faster, and more convenient, eliminating congestion and physical interaction, making it highly suitable for modern smart classrooms and organizations; overall, the system provides a comprehensive, intelligent, and scalable solution that automates attendance management, improves academic discipline, enhances monitoring through parental involvement, and contributes significantly to the advancement of smart education systems and institutional productivity.

Key Words: ***Video Processing, Face Recognition Technology, Face Detection, Face Recognition Attendance System, Automated Attendance System, Real-Time Video Recognition, Haar Cascade Classifier, Local Binary Pattern Histogram (LBPH), Convolutional Neural Network (CNN), Face Identification, OpenCV, Raspberry Pi 3B+, AWS Rekognition, Cloud-Based Attendance, Smart Classroom, Biometric Authentication, Anti-Proxy System, Attendance Analytics, Parent Access and Parental Monitoring, Student Attendance Tracking, Real-Time Notifications, Education Management System.***

I. INTRODUCTION

In the era of rapid internet expansion and digital transformation, computer technology has become an integral part of everyday life, significantly influencing various domains such as education, security, and organizational management. One of the most innovative and rapidly evolving areas in this field is face recognition technology, which combines artificial intelligence and image processing to identify individuals based on unique facial features. Due to its non-intrusive, contactless, and highly adaptable nature, face recognition has gained widespread attention and has been extensively applied in public safety, civil applications, and smart systems. In recent years, traditional attendance systems—such as manual roll calls and paper-based signatures—have proven to be inefficient, time-consuming, and prone to errors and proxy attendance. Alternative methods like RFID, fingerprint recognition, and iris scanning have been introduced; however, these systems often suffer from issues such as congestion, hardware dependency, higher costs, and potential misuse, such as card swapping or scanning delays. Compared to these approaches, face recognition systems offer higher accuracy, improved stability, and the ability to recognize multiple individuals simultaneously without physical interaction, making them highly suitable for modern attendance management. Despite these advantages, challenges such as image blur, pose variations, occlusion, and lighting conditions in real-time video streams still affect system performance, leading researchers to develop advanced models, including Convolutional Neural Networks (CNN) and hybrid architectures like trunk-branch CNN, to enhance robustness and feature extraction. Additionally, techniques involving image preprocessing, artificial data augmentation, and clustering methods based on distance metrics such as Euclidean, cosine, and Kullback-Leibler divergence have been explored to improve recognition accuracy.

This paper proposes an **AI-based Smart Attendance System using Face Recognition** that leverages real-time video processing to automatically detect, recognize, and record student attendance efficiently. The system captures live classroom video, detects faces using algorithms such as Haar Cascade, and recognizes them using methods like Local Binary Pattern Histogram (LBPH) and deep learning models, ensuring accurate and fast attendance marking. The system is further enhanced through cloud integration using AWS services such as Rekognition for face matching, Amazon S3 for

secure image storage, AWS Lambda for backend processing, and DynamoDB for database management, enabling scalability, reliability, and real-time performance. Experimental analysis demonstrates that the proposed system significantly reduces attendance time, minimizes human errors, and eliminates proxy attendance, while improving overall classroom discipline and participation.

Furthermore, a novel feature of the system is the inclusion of a **parent access module**, which allows parents or guardians to monitor their child's attendance records through a web or mobile platform, receive real-time notifications for absences, and track attendance trends over time. This feature enhances transparency, strengthens communication between institutions and families, and promotes accountability among students. By integrating advanced face recognition techniques with cloud computing and user-centric features, the proposed system provides a comprehensive, efficient, and scalable solution for modern attendance management, contributing significantly to the advancement of smart educational environments and institutional productivity.

II. LITERATURE SURVEY

A significant amount of research has been conducted on automated attendance systems using various technologies, each offering unique advantages and limitations. In [3], an automated attendance system integrating face recognition with Radio Frequency Identification (RFID) was proposed, where authorized students are detected as they enter or exit the classroom, and attendance records are maintained systematically; however, the system still depends on physical RFID cards, making it vulnerable to misuse and proxy attendance. In [4], an iris-based biometric attendance system was developed, where users register their iris templates, and attendance is marked by capturing and matching eye images; although accurate, this approach is intrusive, costly, and requires specialized hardware. Another study in [5] implemented a face recognition system using Viola-Jones for detection, Histogram of Oriented Gradients (HOG) for feature extraction, and Support Vector Machine (SVM) for classification, achieving reliable results under varying conditions such as illumination and pose, though it required controlled environments and computational resources. In [6], a comparative analysis between Eigenface and Fisherface algorithms using OpenCV was conducted, where Eigenface showed better performance with an accuracy ranging from 70% to 90%, but the system was sensitive to lighting and facial orientation. Similarly, in [7], a hybrid approach combining Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT) with Radial Basis Function (RBF) classifier achieved an accuracy of approximately 82%, demonstrating improved feature extraction but increased computational complexity.

Other approaches include Near Field Communication (NFC)-based attendance systems, where students use NFC tags to mark attendance via mobile devices; although convenient, such systems are prone to impersonation and require additional hardware. Biometric systems like fingerprint and RFID-based attendance are widely used but suffer from issues such as congestion, hardware dependency, maintenance costs, and vulnerability to misuse. Eigenface-based systems using Haar Cascade classifiers and Principal Component Analysis (PCA) have also been explored, but they are highly sensitive to pose variations. More advanced systems utilize Deep Convolutional Neural Networks (DCNN), FaceNet embeddings, and SVM classifiers to achieve higher accuracy (up to 95%), but they require large and diverse datasets and are affected by lighting and angular constraints. Additionally, fingerprint and speech recognition-based systems integrated with smartphones have been proposed, but these introduce device dependency and variability among users. Template matching approaches combined with Local Binary Pattern Histogram (LBPH) and Viola-Jones algorithms have also been used for efficient face detection and recognition, where unidentified faces are flagged as intruders, improving system security.

Despite these advancements, existing systems often lack scalability, real-time efficiency, user convenience, and comprehensive monitoring features. Most importantly, they do not provide direct access to stakeholders such as parents or guardians. To address these gaps, the proposed system introduces an AI-based face recognition attendance solution that is contactless, efficient, and capable of real-time processing while also incorporating a **parent access module**, enabling parents to monitor their child's attendance, receive notifications for absences, and track attendance trends. This added feature enhances transparency, accountability, and communication between institutions and families, making the system more effective and suitable for modern smart education environments.

III. PROPOSED METHOD

The proposed system presents an advanced **AI-based Smart Attendance System using Face Recognition** that leverages real-time video processing to automate attendance tracking efficiently and accurately. Face recognition serves as the core component of the system, combining face detection and face matching to identify individuals based on unique facial features. The system initially captures facial images or video streams using a camera, detects the presence of faces, and extracts key facial features such as position, size, and structural attributes. These features are then preprocessed through techniques such as grayscale conversion, normalization, and noise reduction to enhance recognition performance. Feature extraction is performed using methods such as Local Binary Pattern Histogram (LBPH), Linear Discriminant Analysis (LDA), and advanced techniques like Gabor wavelet transforms combined with Fisher discriminant analysis, which help minimize intra-class variations and maximize inter-class separability, thereby improving recognition accuracy and robustness. Various recognition approaches—including geometric feature methods, subspace analysis (PCA and LDA), neural networks such as Convolutional Neural Networks (CNN), and Support Vector Machines (SVM)—are analyzed, and an optimal hybrid approach is selected to balance accuracy, computational efficiency, and real-time performance.

The system architecture consists of multiple integrated modules, including video acquisition, data transmission, data storage, face recognition, and user interface modules. The process begins with dataset creation, where multiple images of each student are captured under different conditions and stored in a structured database after preprocessing. During operation, a camera installed in the classroom captures real-time video streams, and face detection is performed using the Haar Cascade Classifier in OpenCV, which identifies and localizes faces within frames. The detected faces are then passed to the recognition module, where LBPH or deep learning-based models compare them with stored facial data to identify individuals. Once a match is found, the attendance is automatically updated in the database, and unrecognized faces are flagged for further verification. The system supports continuous and real-time processing, ensuring

that attendance is marked seamlessly without interrupting classroom activities.

To enhance scalability and performance, the system can be integrated with cloud technologies such as AWS Rekognition for face matching, Amazon S3 for secure image storage, AWS Lambda for backend processing, and DynamoDB for database management. Additionally, the system includes modules such as login authentication for administrators, attendance monitoring dashboards, and automated reporting features. At the end of each session, attendance reports are generated and shared with faculty members via email, and monthly summaries are maintained for analysis. The hardware implementation includes components such as a Raspberry Pi 3B+ for edge processing, a high-resolution webcam for image capture, and supporting peripherals like storage devices and display units, making the system cost-effective and deployable in real-world classroom environments.

A key enhancement of the proposed system is the integration of a **parent access module**, which enables parents or guardians to monitor their child's attendance in real time through a web or mobile application. This module provides detailed attendance reports, percentage tracking, and instant notifications in case of absence, thereby improving transparency, accountability, and communication between institutions and families. Additional features such as anti-spoofing mechanisms, real-time notifications, attendance analytics, and integration with institutional management systems further strengthen the system. Overall, the proposed method provides a comprehensive, efficient, and scalable solution that eliminates proxy attendance, reduces time consumption, enhances classroom discipline, and supports smart education systems through intelligent automation and stakeholder engagement.

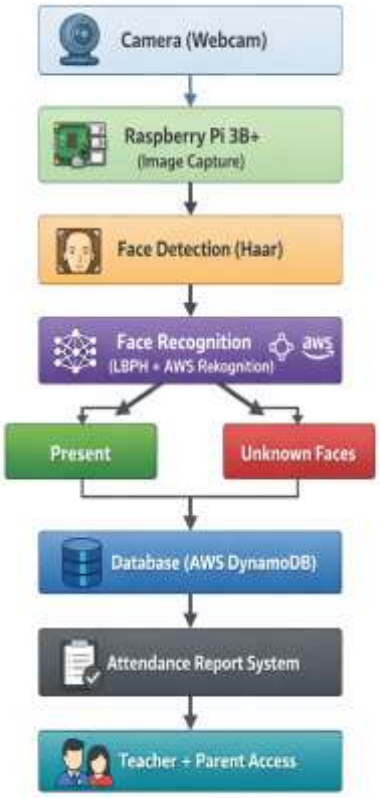
III. METHODOLOGY

The proposed system presents an intelligent and automated attendance management solution using face recognition technology integrated with cloud computing and embedded systems. Based on an extensive literature survey, existing systems were analyzed to identify limitations such as low accuracy, high manual effort, and lack of real-time monitoring. To overcome these issues, an efficient and scalable approach is designed using a combination of image processing, machine learning, and cloud-based services.

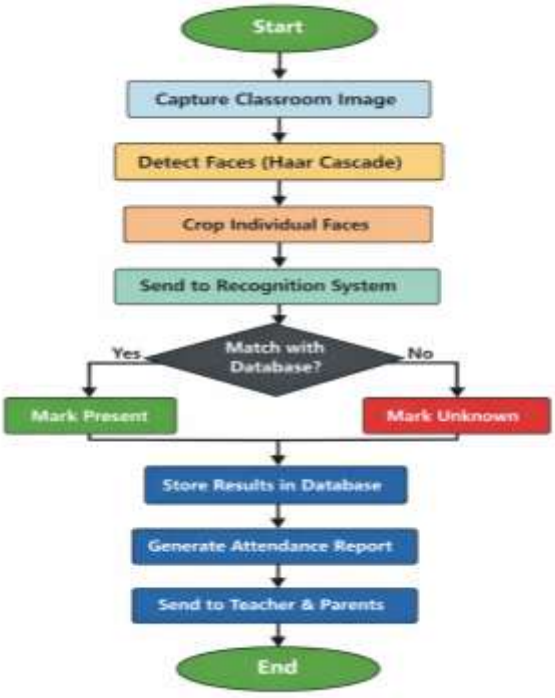
The system is implemented using a Raspberry Pi 3B+ integrated with a high-resolution webcam, which captures real-time classroom images. The face detection process is performed using the Viola-Jones algorithm (Haar Cascade Classifier), which efficiently detects human faces from the captured image. Once faces are detected, the recognition process is carried out using Local Binary Pattern Histogram (LBPH) along with Convolutional Neural Network (CNN)-based cloud recognition through AWS Rekognition for higher accuracy.

The methodology is divided into two main phases: **Student Registration** and **Attendance Processing**.

A. System Architecture Diagram



B. System Flowchart



C. Student Registration Process

The registration process is essential for building the facial database of students. Initially, student details such as name, ID, and class are collected. The system captures multiple images of each student using

the camera module. These images are then uploaded to Amazon S3 along with metadata. An AWS Lambda function is automatically triggered upon image upload, which processes the image, extracts facial features, and generates a unique face print. This face print is a mathematical representation of the student's face and is stored in Amazon DynamoDB along with the corresponding student information. This ensures quick and efficient retrieval during attendance marking.

D. Attendance Processing

The attendance process begins with capturing a real-time image of the classroom. The system detects all faces present in the image and crops them individually for further processing. These cropped images are sent to AWS Rekognition, which analyzes facial features using deep learning models and compares them with stored face prints in the database. If a match is found, the student is marked as present; otherwise, the face is labeled as unknown. The system automatically generates a list of present and absent students. Teachers are given the option to manually verify and correct attendance records if necessary. The final attendance data is stored securely in the cloud database.

E. Hardware Requirements

The system requires minimal and cost-effective hardware components, including:

- Raspberry Pi 3B+
- Logitech C270 Webcam (8MP)
- Power Supply
- 16GB Micro SD Card
- Monitor (Screen)
- Keyboard and Mouse
- HDMI Cable

F. Cloud Integration (AWS Services)

The system leverages multiple AWS services for efficient operation:

- **Amazon S3** for image storage
- **AWS Rekognition** for facial recognition
- **AWS Lambda** for automated processing
- **DynamoDB** for storing face prints and student data

This cloud-based architecture ensures scalability, high accuracy, and real-time processing capabilities.

G. Parent Access and Monitoring Feature (NEW ADDITION)

A key enhancement of the proposed system is the integration of a **Parent Access Module**, which improves transparency and student monitoring. In this feature, parents are provided with secure access (via mobile app or web portal) to view their child's attendance records in real time. The system automatically sends notifications to parents regarding their child's attendance status, including daily presence, absence alerts, and overall attendance percentage. This allows parents to track academic participation and take necessary actions in case of irregular attendance. Additionally, periodic reports can be generated and shared with parents via email or mobile notifications, enhancing communication between educational institutions and families.

IV. SOFTWARE REQUIREMENTS AND IMPLEMENTATION

A. Software Requirements

The successful implementation of the proposed face recognition-based attendance system requires a combination of software tools and development environments that support computer vision, programming, and user interface design.

OpenCV-Python:
OpenCV (Open Source Computer Vision Library) is a powerful and widely used library designed for solving computer vision problems. It supports multiple programming languages such as Python, C++, and Java, and is compatible with various platforms including Windows, Linux, macOS, Android, and iOS. In this project, OpenCV-Python is used for real-time face detection and image processing tasks. It provides efficient implementations of algorithms such as the Haar Cascade classifier for face detection and supports GPU acceleration using CUDA and OpenCL for improved performance.

Visual Studio Code:
Visual Studio Code is a lightweight yet powerful source code editor developed by Microsoft. It supports multiple programming languages and provides features such as syntax highlighting, intelligent code completion, debugging tools, and integrated GitHub support. In this project, Visual Studio Code is used as the primary development environment for writing, testing, and debugging Python scripts related to face detection and recognition.

Qt Creator:
Qt Creator is an integrated development environment (IDE) used for designing graphical user interfaces (GUI). It supports C++, JavaScript, and QML and provides tools such as a visual debugger, UI designer, and code editor with auto-completion features. In this system, Qt Creator is utilized to design the user interface for the attendance monitoring system, making it user-friendly and interactive for lecturers.

B. Implementation

The implementation of the proposed system involves both hardware setup and software execution. The system is deployed on a Raspberry Pi 3B+ integrated with a webcam and other essential components.

Step 1: System Setup

The Raspberry Pi is connected with all required hardware components such as the webcam, power supply, monitor, keyboard, and mouse. The operating system is installed and configured to support Python and OpenCV libraries.

Step 2: Accessing the Attendance System

The user (lecturer) accesses the attendance monitoring system through a graphical user interface (GUI). The lecturer selects the appropriate date and timetable ID to initiate the attendance session.

Step 3: Script Initialization

Once the session is started, a Python script is triggered through the system interface. This script controls the entire face detection and recognition process.

Step 4: Loading Trained Data

The system loads pre-trained face recognition data stored in a .yml file. This file contains encoded facial features of all registered students and is essential for identification.

Step 5: Face Acquisition

The webcam captures real-time images of students in the classroom. These images undergo preprocessing steps such as grayscale conversion and noise reduction, followed by face detection using the Haar Cascade algorithm.

Step 6: Face Recognition

Detected faces are compared with the stored dataset using the LBPH recognizer and cloud-based AWS Rekognition (if enabled). The system identifies each student by matching facial features with the database.

Step 7: Attendance Marking

Once a student is recognized, the system automatically marks their attendance in the database. The attendance record includes details such as student ID, date, and time. Unrecognized faces are flagged for manual verification.

Step 8: Report Generation and Notification

After processing all faces, the system generates an attendance report. This report is stored in the database and sent to the lecturer. Additionally, the system notifies parents through email or mobile alerts, allowing them to monitor their child's attendance in real time.

V. RESULTS AND DISCUSSION

The developed system provides a user-friendly graphical interface using Streamlit, allowing users to efficiently manage attendance through face recognition. The system mainly consists of three modules: student registration, attendance marking, and attendance viewing. In the student registration module, users are required to enter the student's name and roll number and upload a face image. Once the register button is clicked, the image is stored in the dataset folder and the details are saved in the SQLite database. The registered students are displayed in a gallery format with their images resized to a uniform size, ensuring consistency for face recognition. Each student is also provided with a remove option, which allows deletion of both the database record and the corresponding image from the dataset. Additionally, a retrieve student feature is implemented where users can search for a student using their roll number and view their details along with the stored image. This functionality is illustrated in **Fig.1**, which shows the dataset of registered students and the interface for managing them.

Fig.1. Registered Students Dataset and Gallery View

During the attendance process, the user selects the take attendance option and activates the webcam by clicking the start camera checkbox. The system captures live video frames and detects faces in real-time using the face_recognition library. The detected faces are encoded and compared with the stored dataset images. If a match is found, the system identifies the student and displays their name on the video frame. If the face is not registered, it remains unrecognized. Once a student is identified, their attendance is automatically recorded along with the current date and time. The system ensures that attendance is marked only once per day for each student, preventing duplicate entries. The real-time face detection and recognition process is shown in **Fig.2**, where recognized students are highlighted on the screen.

Fig.2. Live Face Recognition for Attendance Marking

The attendance records are stored in the database and can be accessed through the view attendance module. The records are displayed in a structured tabular format containing details such as student name, roll number, date, and time. This allows easy tracking and verification of attendance data. Furthermore, the system provides an option to download the attendance records in CSV format for external use such as reporting or analysis. The attendance table displayed in the interface is shown in **Fig.3**, which represents the successfully recorded attendance data after the recognition process.

Fig.3. Attendance Records Displayed in Tabular Format

Overall, the system demonstrates an effective implementation of face recognition technology for automated attendance management. It eliminates the need for manual attendance marking and reduces the chances of proxy attendance. The system is efficient, easy to use, and capable of handling student data effectively. However, its performance depends on factors such as lighting conditions, camera quality, and the availability of clear facial images. Despite these limitations, the system provides a reliable and accurate solution for modern attendance management.

VI. CONCLUSION

The proposed AI Smart Attendance System using face recognition provides an efficient and automated solution for managing student attendance by integrating advanced face recognition technology with a user-friendly interface, thereby eliminating the need for manual attendance marking and significantly reducing the chances of proxy attendance. The implementation using Streamlit, OpenCV, and the face_recognition library enables real-time face detection and accurate identification of students, while key functionalities such as student registration, face-based attendance marking, student data retrieval, and attendance record management ensure smooth system operation. The use of an SQLite database allows secure storage and easy access to student and attendance data, and additional features like image-based dataset creation, duplicate attendance prevention, and CSV export further enhance usability and practicality. Although the system's performance depends on external factors such as lighting conditions, camera quality, and the clarity of facial images, it demonstrates high accuracy and reliability in controlled environments. Overall, the developed system serves as a cost-effective, scalable, and intelligent solution for modern attendance management, making it highly suitable for educational institutions and organizations seeking automation and improved efficiency.

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